LEARNING STYLES, STUDENT-CENTERED LEARNING TECHNIQUES, AND STUDENT PERFORMANCE: AN EMPIRICAL STUDY

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ABSTRACT

Though other categorizations of learning styles have been widely studied, few researchers have compared learning styles, as categorized by Gregorc, to undergraduate student achievement in agricultural economics courses. Moreover, few studies have explored the affects of instructional strategies, in concert with learning styles, on student achievement. This study does so, using data generated from an undergraduate course in agricultural economics. Results indicate that active learning and problem-based learning techniques, as a supplement to the traditional lecture format, can significantly and positively influence student learning. Additionally, students' learning styles significantly affect their performance in an introductory course in agriculture, resources, and food.

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Introduction

A student's learning style reflects the manner in which he or she assimilates, processes, and recalls information (Whittington and Raven). Diversity in learning styles underscores the need for instructors in higher education to incorporate a variety of teaching methods, curriculum materials, and assessment techniques to foster and support the process of learning (Torres and Cano). Anderson and Adams, for example, challenge educators to recognize learning styles as a significant source of diversity in the classroom and to improve teaching methods accordingly. Many researchers have suggested that their preferred way of learning influences student achievement, learning, and interaction with faculty and classmates.

A variety of psychometric instruments have been developed to determine an individual's learning style, including the Gregorc Style Delineator™ (GSD). Gregorc's instrument is based on mediation abilities theory, which states that our minds receive, process, and express information through channels in an efficient way. Mediation abilities include perception and ordering (Gregorc). *Perception* is described on a continuum between concrete and abstract, and relates to how a person receives information. In contrast, *ordering* relates to how one arranges and uses information. Gregorc suggests an ordering continuum from sequential to random.
These abilities translate into four different mind styles: concrete sequential (CS), concrete random (CR), abstract sequential (AS), and abstract random (AR). [1]

[1] For a detailed description of the four Gregorc styles and students' related instructional delivery preferences, see Schmidt and Javenkoski.

While field-dependence/independence is the most extensively studied learning style characterization, limited empirical results relating to GSD-designated learning styles and student achievement in introductory courses suggest an opportunity for further inquiry. Harasym et al. found no relationship between learning style and student achievement in an introductory anatomy and physiology course. In fact, the authors questioned the validity of the GSD. The lack of empirical results is particularly striking for course offerings in Colleges of Agriculture. In their study, Schmidt and Javenkoski found few significant differences among student ratings of six instructional strategies based on GSD-determined learning style. However the class as a whole believed the use of a combination of teaching methods in an introductory course in food science and human nutrition was effective. Also, no significant differences in course grades were observed.

Studies relating characteristics of students, their learning styles, and key instructional methods are also limited. Students in an introductory animal sciences course demonstrated no significant variation in performance or perceptions of teaching performance based on their preferred means of learning (Garton et al.). Using data from students enrolled in selected animal science courses, Hoover and Marshall investigated the relationship between certain student characteristics (e.g., gender, academic major) and learning style, though their study did not consider student performance. Schmidt and Javenkoski's recent study explores student responses to six different instructional strategies used in a food science and human nutrition course. Data from a limited sample of freshmen enrolled in an introductory agricultural economics course showed no significant variation in test performance and overall perceptions of lecture and multimedia instruction based on learning style (Marrison and Frick). The writer Thomas Carlyle originally described economics as "the dismal science." As such, instructors' use of teaching strategies in agricultural economics may be particularly important toward fostering student learning of such potentially “dreary” subject matter.

The purpose of this study is to explore the relationship among learning styles, key student characteristics, and selected teaching strategies on student performance in an introductory agricultural economics course. Teaching strategies considered include such student-centered learning activities as small group problem/case analysis, active learning techniques, a class web page, computer-based individual problem solving, and a web-based “mastery” test.

Methods

The Gregorc Style Delineator was administered to 186 undergraduate students enrolled in the Economics of Resources, Agriculture and Food (ACE 100) in the College of Agricultural, Consumer and Environmental Sciences at the University of Illinois at Urbana-Champaign in the fall semester of 1999. The course is designed to introduce students in the college to fundamental principles of microeconomics and macroeconomics. Concepts relating to demand, production and supply, elasticity, markets, and trade are presented and applied in the analysis of decisions regarding growth and development, resources, trade, the environment, policy, and agribusiness.

A student-centered learning environment was fostered, using a variety on instructional methods, to promote a solid understanding of basis economic concepts fundamental to student success in subsequent course offerings. A series of web-based exercises/problems were available to students to supplement the classroom material. Discussion sessions provided students with an opportunity to engage in issues relating to agriculture, resources, and food by solving problems and mini-cases in small groups. The teaching team assigned students to small groups based on diverse learning styles, class rank, gender, farm background, and academic major. The instructor used computer-based lecture notes in the classroom, which were also available to students via the class web site. Active learning in the classroom was supported by daily "neighbor questions," in which groups of two to four students solved problems in lecture related material presented during the previous class. Also, students were randomly selected to participate in the "fishbowl" each class period. Participating students were encouraged to engage in the material by providing feedback, answering questions, and fostering discussion. Finally, students were required to complete a web-based "mastery test" of key economic concepts and ideas presented in the course prior to semester's end. Successful completion of the mastery test required a score of 100 percent, and students were allowed multiple attempts.

Mid- and end-of-semester evaluations provided students with the opportunity to evaluate the various strategies and active learning techniques used by the teaching team. Students provided Likert scale ratings of how much they learned from and enjoyed each activity.

Students' final course grade was based on the following weights: a total of 44 percent for three midterm examinations, 24 percent for the final examination; 10 percent for the web-based homework exercises, 19 percent for discussion session activities, and 3 percent for neighbor questions.

Results from the GSD were analyzed using one-way analysis variance (ANOVA F-test with an "-level of 0.05) to explore the relationship between students' preferred learning style and both student performance on each graded activity and the various instructional strategies used in the course.[2]

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[2] Since individual responses regarding whether students "enjoyed" and "learned from" each instructional strategy were highly correlated, the analysis considers "learned from" ratings only.

Ordinary least squares regression analysis is used to explore the influence of key variables on students' course grades. Students' overall course performance can be expressed as:

(1) $G_i = f\,(CHAR_i, LS_i, INST_i)$,

where G_i is the student's course grade, $CHAR_i$, is a vector of individual student characteristics such as gender and class rank, and LS_i, is the student's preferred learning style. $INST_i$ is a vector of instructional strategies expressed through either student ratings of how much they learned (for non-graded activities), or through the student's actual grade in the activity. Specifically, performance variables were selected based on initial relationships suggested in the ANOVA , on preliminary significance testing, and to prevent multicollinearity. They are represented by students' Likert scale ratings (from 1 = very low, to 5 = very high) of the degree to which they learned from the lectures, group discussion sessions, textbook, and the class web page. Performance variables also include the student's grades for the web-based homework problems, discussion session activities, and neighbor questions. Gender and farm background are represented in the model as binary variables. Class rank and academic major are represented as categorical variables, as is learning style (i.e., CS =1, CR = 2, AS = 3, and AR = 4).

Results and Discussion

The objective of this study is to explore the relationship among student learning styles, instructional strategies, and student performance in an introductory course in agriculture, resources and food. Table 1 presents the learning style profile of the class. Approximately 38 percent of students indicate a concrete sequential learning style. The remainder of the class is represented by reasonably similar distributions among concrete random, abstract sequential, and abstract random. The dominance of CS learners is consistent with earlier studies (Schmidt and

Javenkoski; Harasym et al.). Of the 186 undergraduate students, 53.2 percent are male and 46.8 percent are female, while 37.6 percent have a farm or farm-related background. Approximately 54 percent are freshman, 28 percent are sophomores, 14 are juniors, and 4 percent are seniors, all in the College of Agricultural, Consumer and Environmental Science.

Analysis of Variance

Results regarding the influence of learning styles on student ratings of how effectively they believed that they learned from various instructional strategies are provided in Table 2. Surprisingly, only students' ratings for the mastery test showed a significant difference among learning styles. AS and CS learners appeared to learn more from the mastery test than their CR and AR counterparts. Students with a sequential *ordering* orientation (vs. random) tend to prefer programmed and computer-assisted instruction, and simulated experiences. Though this result makes intuitive sense, it is interesting that no significant differences among learning styles exist for student perceptions of learning through any of the other instructional strategies considered.

Learning can also be assessed through student performance in graded activities. Results of the ANOVA exploring the relationship between learning styles and student performance are summarized in Table 3. Significant differences among learning styles are demonstrated for all graded activities, except the group discussion sessions.

Students with a concrete (vs. abstract) *perception* orientations performed significantly better on the web-based homework exercises. These exercises challenged students' individual problem solving skills through practical applications of the economic theory presented in the classroom. CS learners prefer direct, hands-on experience with the material and may have exhibited better attention to detail in completing the problems. Likewise, CR learners prefer concrete applications of concepts through practice and examples, are creative problem solvers, and enjoy learning independently.

Interestingly, CS learners performed significantly better on the neighbor questions, while AR learners did significantly less well. In the neighbor question format, the instructor posed a written question and asked small groups of students to discuss, develop, and submit their answer. The answers were then graded on a “correct” or “incorrect” basis. CS learners may have responded well to the neighbor question format in that they tend to see situations as “right and wrong”, are attentive to detail, and readily follow step-by-step directions. In contrast, AR learners often prefer a less structured learning environment, as well as assignments that allow reflection time. This subset of students may find distasteful an exercise that requires determining the correct answer within a time constraint.

As expected, no significant difference is evident for student group discussion session activities based on learning style. Students were assigned to groups for the duration of the semester based on diversity among learning styles, gender, farm background, academic major, and other characteristics. The results suggest that this strategy successfully mitigated performance differences across groups due to learning styles.

Examinations in ACE 100 consisted of both multiple choice and true/false questions. Students with concrete *perception* orientations performed at a higher level on the three midterms and final examination.[3] Once again, the disparity between CS and AR learners is noteworthy. These results are inconsistent with previous research involving Gregorc learning styles, where significant differences were not generally observed for students in introductory or upper level

[3] Since examinations represented 68 percent of the overall course grade, student test performance and course performance were highly correlated.

animal science courses (Borcher, Pinckey, and Clemens; Garton et al.). However, as Schmidt and Javenkoski suggest, AR learners may not care for the multiple choice or true/false question format, in that they generally dislike restrictions created by guidelines and rules. [4]

Regression Analysis

Regression analysis is used to investigate the explanatory power of learning style, student characteristics, and several key instructional strategies on student performance. Several studies have explored the relationship among student characteristics and learning styles and preferred learning activities, with inconsistent results (e.g. Rollins; Hoover and Marshall). Though the ACE 100 teaching team provided students with a wide variety of examples and applications, students with farm backgrounds may be more familiar with the agriculture and food system, and may as a result outperform their non-farm classmates. The potential influence of the class rank variable is ambiguous. Upperclassmen may be better prepared to deal with the rigors of the class than freshmen, but postponing such an introductory course until later in their programs may indicate a lack of acuity with economic theory. Results demonstrate that none of the student's characteristics considered in this study are highly correlated with their learning styles.

Students' preferred learning style is expected to provide an important indicator of their overall performance in the course. Since learning style is strongly correlated with performance on examinations and the mastery tests, these instructional strategies are excluded from the model. However, the influence of other strategies such as course web page, individual computer

[4] Schmidt and Javenkoski perform an analysis similar to that presented in Tables 2 and 3, though students with GSD learning style scores less than 32 were excluded from their analysis to ensure that only students with one very dominant learning style were considered. In contrast, our study reports results based on the student's highest score, whether above or below 32. Though not reported here, we repeated our analysis with a reduced sample per Schmidt and Javenkoski. However, this resulted in no changes in relative rankings or significance levels.

problem-solving exercises, group discussion sessions, and the neighbor questions are investigated in the model.

Given that student performance is complex and often a function of random variables, the ability of the model to explain approximately 62 percent of a variation in overall course grade seems reasonable. While the effects are not significant, the signs of the parameter estimates indicate that males may have performed better than females, as did upperclassmen and students with farm backgrounds. The coefficient signs also indicate that students who reported learning from the lectures have higher final grades, while those who indicated that small group problem solving and the textbook enhanced their learning experience performed less well. Again, however, these effects are not significant.

The five remaining variables in the model have significant explanatory power. Students who reported that they learned from the class web page performed significantly less well in the course than their counterparts. The web page provided a venue for communicating with the teaching team other than office hours, examples of and solutions for midterm and final examinations from prior course offerings, and access to downloadable versions of the instructors' lecture slides. Perhaps students relied on the web-accessible material instead of information and learning opportunities provided in the classroom setting. Students who performed well in the homework exercises, discussion session assignments, and neighbor questions achieved higher overall course grades. The signs of the parameter estimates are all positive and the effects are highly significant. Though these activities in total represent only 32 percent of the students' course grade, the results underscore the importance of an instructional approach that encourages active learning and engaging students in the course material. And finally, the students' preferred learning style has an important influence on performance. As initially suggested in the ANOVA, concrete sequential learners performed better than their abstract random counterparts. This difference is consistent over many course activities, suggesting that the subject matter may be less suited to abstract random learners. [5]

Summary

In conclusion, the results of this study suggest that active learning and problem-based learning techniques can significantly and positively influence student learning. Also, this study suggests that learning styles are important factors in student learning and performance in an introductory undergraduate course in agriculture, resources, and food. Unlike Harasym et al., we found that there is a relationship between Gregorc learning styles and student achievement, and that both bipolar scales comprising four learning styles are important. In other words, *perception* orientation has explanatory power. As such, this study provides an important foundation for additional empirical research, and has important implications for educators. Certain instructional strategies do contribute to student performance, as does a student's learning style when identified using the GSD. Moreover, attention to student diversity when assembling teams for group problem solving can mitigate the influence of learning styles on performance differences.

However, additional research and replication of these findings is warranted. Student learning and performance is a complex process. Instructors in have an important responsibility to recognize those factors that influence student success and to incorporate a variety of instructional strategies and assessment methods to foster and support the learning process.

[5] Though not reported here, a similar model restricted to only demographic variables and a learning style regressor exhibited significantly poorer explanatory power than the current model (adjusted $R^2 = 0.07$).

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Table 1: Learning Style Profile for a Class of 186 Undergraduates

Learning Style	% of Class for which Style is Dominant	Gregorc Style Delineator Score	
		Mean	Standard Deviation
CS -Concrete Sequential	37.65	26.78	5.74
CR -Concrete Random	16.47	24.55	5.47
AS - Abstract Sequential	18.24	24.85	4.88
AR -Abstract Random	19.41	24.00	5.40

Notes: 8.23 percent of students exhibited no dominant learning style. The GSD ranks a number of word associations in a matrix and develops a numerical total for each of the four learning styles. The dominant style is associated with the largest number.

Table 2: Instructional Strategies - Results of One-Way ANOVA

Item	**CS** (n=50)	**AS** (n=19)	**CR** (n=16)	**AR** (n=22)	**P-value**
Lecture	4.02 " 0.82	3.89 " 0.81	3.63 " 0.72	3.59 " 0.85	0.13
Discussion	3.92 " 0.85	4.11 " 0.66	3.81 " 0.83	4.00 " 0.93	0.74
Textbook	3.16 " 1.20	2.89 " 1.10	2.75 " 1.13	3.32 " 1.04	0.39
Web Site	3.38 " 1.01	3.32 " 1.16	3.19 " 1.17	3.41 " 1.22	0.93
PC Exercises	3.58 " 1.05	3.63 " 0.90	3.13 " 1.41	3.64 " 1.05	0.44
Neighbor Questions	2.71 " 1.01	2.88 " 0.85	2.87 " 1.30	2.95 " 0.89	0.78
Mastery Test	3.08 " 0.83	3.11 " 0.81	2.63 " 0.96	2.33 " 1.15	0.01***
Syllabus	4.02 " 0.84	3.83 " 1.03	4.19 " 0.75	4.00 " 0.94	0.65
Lecture Notes	4.24 " 0.97	4.59 " 0.80	4.50 " 0.63	4.53 " 0.61	0.29

Note: Asterisks indicate significance at the 10% (*), 5% (**), and 1% (***) levels, respectively.

Table 3: Student Performance - Results of One-Way ANOVA

Item	**CS** (n=53)	**AS** (n=24)	**CR** (n=17)	**AR** (n=24)	**P-value**
PC Exercises	93.51 " 10.29	87.17 " 16.70	94.07 " 11.30	82.29 " 21.13	0.01***
Neighbor Questions	59.44 " 14.23	52.06 " 18.58	56.38 " 15.61	45.08 " 19.47	0.01***
Discussion	91.03 " 5.35	89.44 " 8.26	89.38 " 5.77	88.18 " 8.78	0.37
Midterm Exams	71.41 " 9.43	67.43 " 9.05	71.21 " 9.75	59.67 " 9.10	0.00***
Final Exam	79.38 " 13.62	75.29 " 10.63	78.29 " 8.96	68.58 " 10.82	0.00***
Course	82.72 " 8.68	78.58 " 9.17	81.67 " 6.80	72.67 " 8.96	0.00***

Note: Asterisks indicate significance at the 10% (*), 5% (**), and 1% (***) levels, respectively.

Table 4: Results of OLS Regression Analysis of Course Grade

Explanatory Variable	Coefficient
Intercept	34.91*** (5.03)
Demographic Characteristics	
Academic Major	-0.000 (-0.51)
Gender	-0.67 (-0.66)
Farm Background	1.01 (0.99)
Class Rank	0.55 (1.02)
Instructional Strategies – Student Rankings	
Lecture	0.30 (0.51)
Small Group Problem Solving	-0.53 (-0.91)
Textbook	-0.32 (-0.77)
Class Web Page	-0.78* (-1.76)
Instructional Strategies – Student Performance	
Homework Exercises	0.22*** (5.24)
Discussion Session Activities	0.29*** (5.24)
Neighbor Questions	0.11*** (3.01)
Learning Style	-1.49*** (-3.73)

Notes: Adjusted R^2 = 0.62, Prob >F = 0.00. Asterisks indicate significance at the 10% (*), 5% (**), and 1% (***) levels, respectively.